Probing Spin Charge Relation by Magnetoconductance in One-dimensional Polymer Nanofibers

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Introduction

The polymer nanofibers are one dimensional organic hydrocarbon systems where the non-linear local excitations such as solitons, polarons and bipolarons were predicted based on the electron-phonon interactions. We discovered the distinctive zero MC in polyacetylene (PA) nanofibers while the finite MC in polyaniline (PANI) and polythiophene (PT) nanofibers. The universal scaling behavior and the zero (finite) MC in PA (PANI and PT) nanofibers provide evidence of Coulomb interactions between spinless charged solitons (interacting polarons which carry both spin and charge).

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Experimental

Single polymer fibers of ~50 nm in diameter and a few micrometers in length, were deposited on top of 2 μm spacing platinum electrodes. The PA and PT fibers were doped with iodine from vapor phase right before the transport measurement. PANI fibers were exposed to the nitric acid vapor. The MC of the conducting polymer nanofibers up to H=35 T were measured by using a resistive magnet at the NHMFL.

Results and Discussion

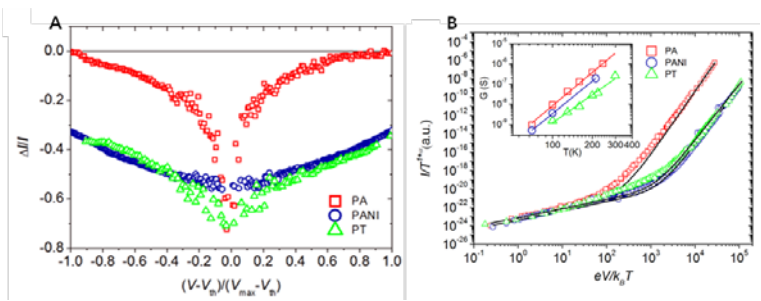

Figure 1 (A) MC of PA, PANI and PT at 35 T vs the scaled excitation voltages (B) Collapsed *I -V* curves for PA, PANI, and PT nanofiber following universal scaling. The inset shows temperature-dependent conductance follows the power law $G(T) \propto T^{\alpha}$.

For PA, the magnitude of MC decreases to zero with increasing bias voltage. For the 1-D structure prohibits orbital motion, the magneto insensitive conduction is related to spinless charged carriers. It confirms that the spinless charged soliton de-confinement conduction in high electric field is responsible for the zero MC [1]. For PANI and PT nanofibers, on the other hand, the MC does not become zero in the limit of the highest applicable voltages, although it is also negative and its magnitudes tend to decrease with bias voltages. The saturating zero MC of PA is distinctive to the results of other polymer nanofibers. Fig. 1B shows Luttinger liquid (LL) behavior of strictly 1-D systems in these polymer nanofibers. The LL characteristics observed in 1-D systems indicate the importance of electron-electron interaction as well as the electron-phonon interaction.

Conclusions

The various quasiparticles which have characteristic spin-charge relation play roles for conduction processes microscopically in different ways. Liberated spinless charged solitons results zero MC in PA nanofibers at high electric field. Coulomb interactions between the local excitations formed by the electron-phonon interaction in 1D conducting polymer nanofibers show the LL behavior.

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